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BRUCE NGS "B" UNIT 5 IN-SERVICE INSPECTION OF CONCRETE CONTAINMENT BOUNDARY (1990)

Report No. 90-333-K

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ABSTRACT

An inspection of the concrete containment boundary of the Bruce NGS "B" Unit 5 reactor building and associated portion of the fuelling machine duct was carried out in November 1990. The concrete appeared to be in good condition, with the exception of a few minor cracks in the perimeter walls and the girders and a debonded repair in the north end of the east boiler room of the reactor building. Overall, no significant change was observed in the condition of the concrete since the previous inspection conducted in 1987.

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To Mr. K.F. Chiu
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Attn: Mr. S. Chu

BRUCE NGS "B" UNIT 5
IN-SERVICE INSPECTION OF
CONCRETE CONTAINMENT BOUNDARY (1990)

1.0 INTRODUCTION

An inspection of the accessible exterior concrete containment boundary of the Bruce NGS "B" Unit 5 reactor building and associated portion of the fuelling machine duct was carried out from November 13 to 15, 1990. The inspection, which followed the work plan prepared by the Central Production Services Division (CPSD), consisted of visual observation and nondestructive testing. The results of the inspection[1] conducted in 1987 were reviewed and the areas that exhibited cracks or deterioration were reinspected to determine what changes had occurred since 1987. The results of the inspection are summarized in this report.

2.0 INSPECTION RESULTS

The visual observations are summarized in Tables 1, 3 and 4. The nondestructive test results are given in Table 2. The locations inspected are listed below:

(a) Accessible areas on the exterior of the reactor building (Tables 1 and 2, Figures 1 to 7).

(b) High stress areas on the exterior of the reactor building (Tables 1 to 3, Figure 8).

(c) Accessible areas of the breakout panel (Table 1, Figure 9).

(d) Concrete around randomly selected embedded parts - EP - (Table 1).

(e) Concrete in the rooms located in the reactor building basement (Table 1).

(f) Concrete around Air Locks 2 and 5 (Table 1).

(g) Concrete around the post-tensioning anchorage system of the main girders (Tables 1, 2 and 4, Figures 10 to 12).

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[1] Research Division Report 87-291-K, "Bruce NGS "B" RB 5, In-Service Inspection of Concrete Containment Boundary".

(h) Concrete around the embedded parts for the preheater containment enclosure anchorages (Table 1, Figures 13 to 17).

(i) Concrete around the primary heat transport pump supports (Table 1).

(j) Concrete around the steam generator supports (Table 1, Figures 18 and 19).

(k) Accessible areas of the fuelling machine duct wall in the vicinity of Unit 5 (Table 1, Figures 20 to 22).

3.0 SUMMARY

Cracks not previously reported were identified in the perimeter wall of the reactor building (Figures 1 to 4). These cracks were similar to those reported in 1987 and probably have not developed recently. Deposits, similar to efflorescence, were observed on the perimeter wall at a few cracks and penetrations (Figures 6 and 7). A visual investigation could not identify the source of the deposits. At present, these deposits do not appear to be significant; however, they should be monitored during future inspections.

A repair previously made to the north wall of the east boiler room, adjacent to the preheater enclosure, was found to be debonded, and it may require repair. Cracks present in the concrete around the primary heat transport pump supports appeared to have increased in number since the 1987 inspection. The increase in cracks does not appear to be significant. Cracks were also observed extending from the embedded parts for the steam generator braces (Figures 18 and 19). A few cracks were observed in the fuelling machine duct, and a repair made to a crack reported previously was in good condition (Figures 20 and 21).

The nondestructive test results were of the same order as those obtained in 1987, and indicated that the concrete was of good quality and relatively unchanged since 1987.

4.0 CONCLUSIONS

The concrete appeared in good condition, with the exception of a few minor cracks in the perimeter walls and the girders and a debonded repair in the north end of the east boiler room of the reactor building. The presence of these cracks is not considered significant. Although additional cracks were identified, no significant change was observed in the condition of the concrete since the previous inspection conducted in 1987. The additional cracks identified do not appear to have developed recently. White deposits, identified on the perimeter wall, should be monitored during future inspections.

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Table 1

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary

Inspection Location	Observations
(a) Accessible areas on the exterior of the reactor building	- The location of cracks identified on the exterior of the reactor building are shown in Figures 1 to 4. - The cracks previously identified were reinspected and any additional cracks noted. - In general, the cracks were hairline in width (<0.15 mm wide) and many were covered with paint (Figure 5). - Cracks identified during this inspection appeared similar to the cracks previously reported and have probably not developed recently. - At four locations on the perimeter wall, white deposits similar to efflorescence, were observed on the concrete (Figures 6 and 7). These areas were generally associated with embedded parts or cracks. Similar deposits were observed in 1987. Visual inspection could not confirm the source of the deposits.
(b) High stress areas on the exterior of the reactor building	- The observations made of the high stress areas are summarized in Table 3 and Figure 8. - There appeared to be no change since 1987 in the condition of the concrete in the areas inspected.
(c) Accessible areas of the breakout panel	- The location of cracks identified on the exterior of the breakout panel are shown in Figure 9. - In general, very little change was observed in the condition of the concrete. The newly identified cracks appeared similar to the cracks previously reported and have probably not developed recently.
(d) Concrete around randomly selected embedded parts	- A few minor hairline cracks were present in the concrete around the embedded parts inspected in the perimeter wall.
(e) Concrete in the rooms located in the reactor building basement	- The wall of the fuelling machine duct was visually inspected by CPSD staff from the moderator heat exchanger rooms. - No significant cracks or deterioration of the concrete was observed.
(f) Concrete around Air Locks 2 and 5	- As reported in 1987, cracks extended from the upper portion of Air Lock 2. - No cracks were noted around Air Lock 5.
(g) Concrete around the post-tensioning anchorage system of the main girders	- The condition of the concrete in the vicinity of the post-tensioning anchorages is summarized in Table 4. - At the ends of the girders, the cracks were randomly orientated (Figure 10). - At the anchorage zones, cracks extended from the anchors (Figure 11). - Along the length of the girders, vertical cracks were present. - Leakage of grease was observed at one of the anchor caps and at a vent hose embedded in the concrete. The anchor cap was removed and the tendons inspected. No evidence of rust or deterioration of the tendons was observed (Figure 12).

Table 1 (cont'd)

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary

Inspection Locations	Observations
(h) Concrete around the embedded parts for the preheater containment enclosure anchorages	- The locations of cracks are shown in Figures 13 to 17. - Cracks in the concrete not previously reported were identified in some locations. It could not be determined whether these cracks have developed since the inspection conducted in 1987. - A debonded repair was identified in the north wall of the boiler room adjacent to the northeast preheater enclosure.
(i) Concrete around the primary heat transport pump supports	- The concrete around the primary heat transport pump supports was dirty which made viewing the cracks and estimating their widths difficult. - Randomly orientated cracks were observed in the floor. - Transverse cracks were observed in the transverse griders. - The size and number of cracks observed in this area may have increased somewhat since the 1987 inspection.
(j) Concrete around the steam generator supports	- The concrete in the vicinity of the steam generator support beams and the horizontal braces for the steam generators was visually inspected (Figure 18). - No significant cracks were observed in the concrete around the steam generator support beams. - Cracks up to 0.50 mm wide were observed in the concrete, extending from the embedded parts for the horizontal bracing of the steam generators (Figure 19).
(k) Accessible concrete on the exterior of the fuelling machine duct walls in the vicinity of Unit 5	- Only the south wall of the duct was accessible for inspection (Figures 20 to 22). - Horizontally and vertically oriented cracks were observed in the concrete at Elevation 579'. - There appeared to be no change in these cracks since the 1987 inspection. - A crack at the construction joint between Units 5 and 6, which was reported in 1987, was found to be repaired. The repair was sound and appeared in good condition. - At Elevation 591', a small number of cracks were observed in the concrete. These cracks were less than 0.25 mm wide.

Table 2

Bruce NGS 'B' Unit 5
In-Service Inspection of Concrete Containment Boundary
Nondestructive Test Results

Inspection Location	1987 Results Rebound Number*	1987 Results Relative Strength** (MPa)	1990 Results Rebound Number*	1990 Results Relative Strength** (MPa)
Perimeter Wall				
North wall, El. 615' Between Col Lines J and L	48.2	47	50.9	52
North wall, El. 639' Between Col Lines D and G	49.7	50	49.4	50
North wall El. 639' Between Col Lines J and L	48.6	48	49.7	50
East wall El. 615' Between Col Lines 8 and 9	-	-	51.8	53
East wall El. 639' Between Col Lines 9 and 10	-	-	53.0	55
South wall El. 639' Between Col Lines D and G	45.9	43	54.0	57
West wall El. 615' Between Col Lines 9 and 10	45.6	43	49.9	50
West wall El. 639' Between Col Lines 7 and 8	48.9	48	50.7	52
Main Girders				
East Girder				
- west side of north end El. 675'	-	-	52.0	54
- east side of north end El. 696'	-	-	51.5	53
- east side of south end El. 675'	-	-	54.8	59
- east side of south end El. 696'	-	-	52.5	54
West Girder				
- east side of north end El. 675'	-	-	52.5	54
- east side of north end El. 696'	-	-	50.4	51
- west side of south end El. 675'	-	-	56.6	>59
- south end of girder El. 696'	-	-	49.4	50
Wall of Fuelling Machine Duct				
Elevation 579' (south wall)				
- west of construction joint between Units 5 and 6	47.9	43	52.0	54
- east of construction joint between Units 5 and 6 (repaired area)	42.0	37	50.3 (concrete) 57.0 (repair)	51 >59
- west of construction joint near Col 9I 5N	46.8	45	49.3	50
- west end of duct	-	-	51.5	53
Elevation 591' (south wall)				
- east of construction joint near Col 9I 5N	41.1	36	49.7	50

* The rebound number reported is the average of ten readings.

** The impact hammer does not give an absolute value for the strength of the concrete. It actually gives a relative strength value, based on the surface concrete, which can be used for comparison purposes.

Table 2 (cont'd)

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary
Nondestructive Test Results

Inspection Location	Test Results Estimate of Crack Depth Using Ultrasonic Pulse Velocity Readings (mm)
Vertical crack in north perimeter wall El. 639' between Col Lines J and L (Heat Transport Monitor Room) - Ultrasonic pulse velocity in sound concrete 4400 m/s*	130 150 210 170 150
Horizontal crack in west perimeter wall El. 639' between Col Lines 7 and 8 - Ultrasonic pulse velocity in sound concrete 3700 m/s*	150 150 150 170 130 140
Horizontal crack in High Stress Area 4 at El. 663' - Ultrasonic pulse velocity in sound concrete 4200 m/s*	270 210 190 180 180
Vertical crack in Fuelling Machine Duct wall El. 579' between Col 9I 5N and 9I 5P - Ultrasonic pulse velocity in sound concrete 4400 m/s*	180 180 180 210 230

* Ultrasonic pulse velocity readings in sound concrete were taken in the vicinity of the cracks. These values were used to calculate the estimated depth of crack penetration reported above.

Table 3

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary
Inspection of High Stress Areas

The high stress areas, as identified in the work plan prepared by CPSD, are shown in Figure 8.

High Stress Area Elevation 615'	Observations
1	- Vertical crack in north wall. - Horizontal crack in west wall.
2	- Vertical crack present.
3	- No cracks noted.
4	- Vertical crack in north wall. - No cracks noted in east wall.
5	- Not accessible.
6	- Diagonal crack in south wall. - Horizontal crack in west wall.
7	- Randomly orientated hairline cracks.
8	- No cracks noted.
9	- Cracks extend from EPs.
Elevation 639'	
1	- Horizontal crack in north wall. - Three horizontal cracks in west wall.
2	- Minor randomly orientated cracks.
3	- Minor randomly orientated cracks.
4	- Horizontal crack in north wall (width = 0.5 mm). - Horizontal crack in east wall.
5	- Three horizontal cracks in east wall. - South wall not accessible.
6	- Horizontal crack in south wall. - Two horizontal cracks in west wall.
7	- Not accessible.
8	- No cracks noted.
9	- Diagonal crack present.

Table 3 (cont'd)

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary
Inspection of High Stress Areas

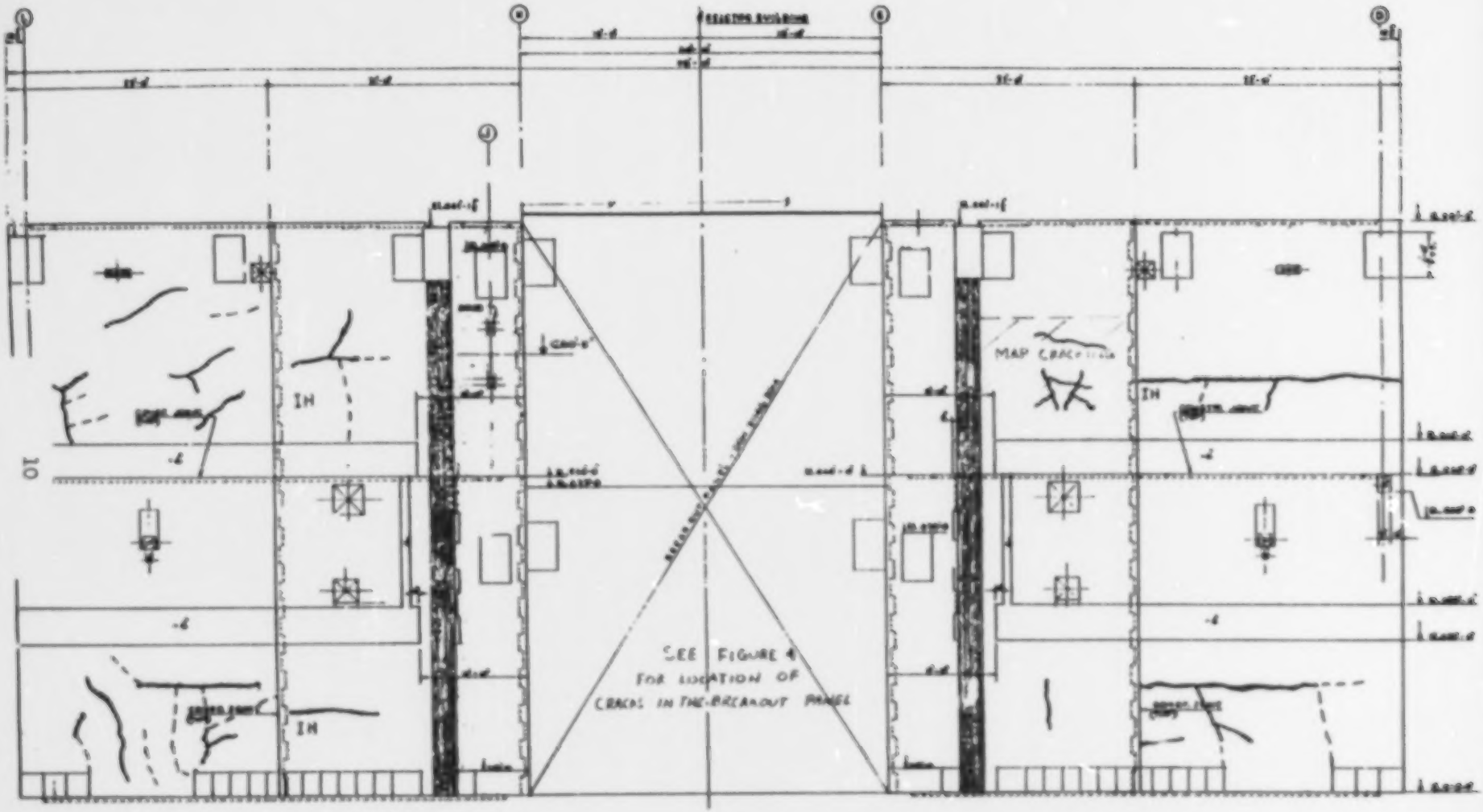
The high stress areas, as identified in the work plan prepared by CPSD, are shown in Figure 8.

Elevation 666'	Observations
1	- Three horizontal cracks extend across the corner.
2	- Horizontal crack present.
3	- Randomly oriented cracks present (pattern cracking).
4	- Horizontal cracks extend across the corner.
5	- No cracks noted in the east wall. - South wall not accessible.
6	- No cracks noted in the south wall. - Horizontal crack and possible cold joint in west wall.
7	- No cracks noted, however, possible cold joint present.
8	- No cracks noted.
9	- Vertical crack present.

Table 4

Bruce NGS "B" Unit 5
In-Service Inspection of Concrete Containment Boundary
Inspection of Main Girders and Post-Tensioning Anchorages

Location	Elevation	Remarks
West Girder - north end	678'	- A few minor cracks (widths <0.10 mm) extended from the anchorages. - Leakage of grease was reported from the anchor cap for the greased tendons. The anchor cap was removed and the tendons visually appeared in good condition with no evidence of corrosion or deterioration of the concrete. - Leakage of grease was observed from a vent tube embedded in the concrete above the anchorage.
	693'	- A few diagonal cracks extended from the anchorage zones. - At the end of the girder, randomly oriented cracks were observed.
West Girder - south end	678'	- A few minor cracks extended from the anchorage zones.
	693'	- A few minor cracks extended from the anchorage zones. - At the end of the girders, horizontal cracks were observed.
East Girder - north end	678'	- A few minor cracks extended from the anchorages.
	693'	- The west side of the girder was not accessible; however, from a distance, no major cracks or deterioration of the concrete was observed. - On the east side of the girder, diagonal cracks extended from the anchorage zones. - Horizontal cracks were observed in the end of the girder.
East Girder - south end	678'	- A few minor cracks extended from the anchorages.
	693'	- The west side of the girder was not accessible; however, from a distance, no major cracks or deterioration of the concrete was observed. - On the east side, one small crack extended from the anchorage. - At the end of the girder, a horizontal crack was observed.
East and west girders East and west elevations	All	- The accessible portion of the top and sides of the girders was inspected at various elevations. - Vertical cracks, extending across the top of the girders, were observed.



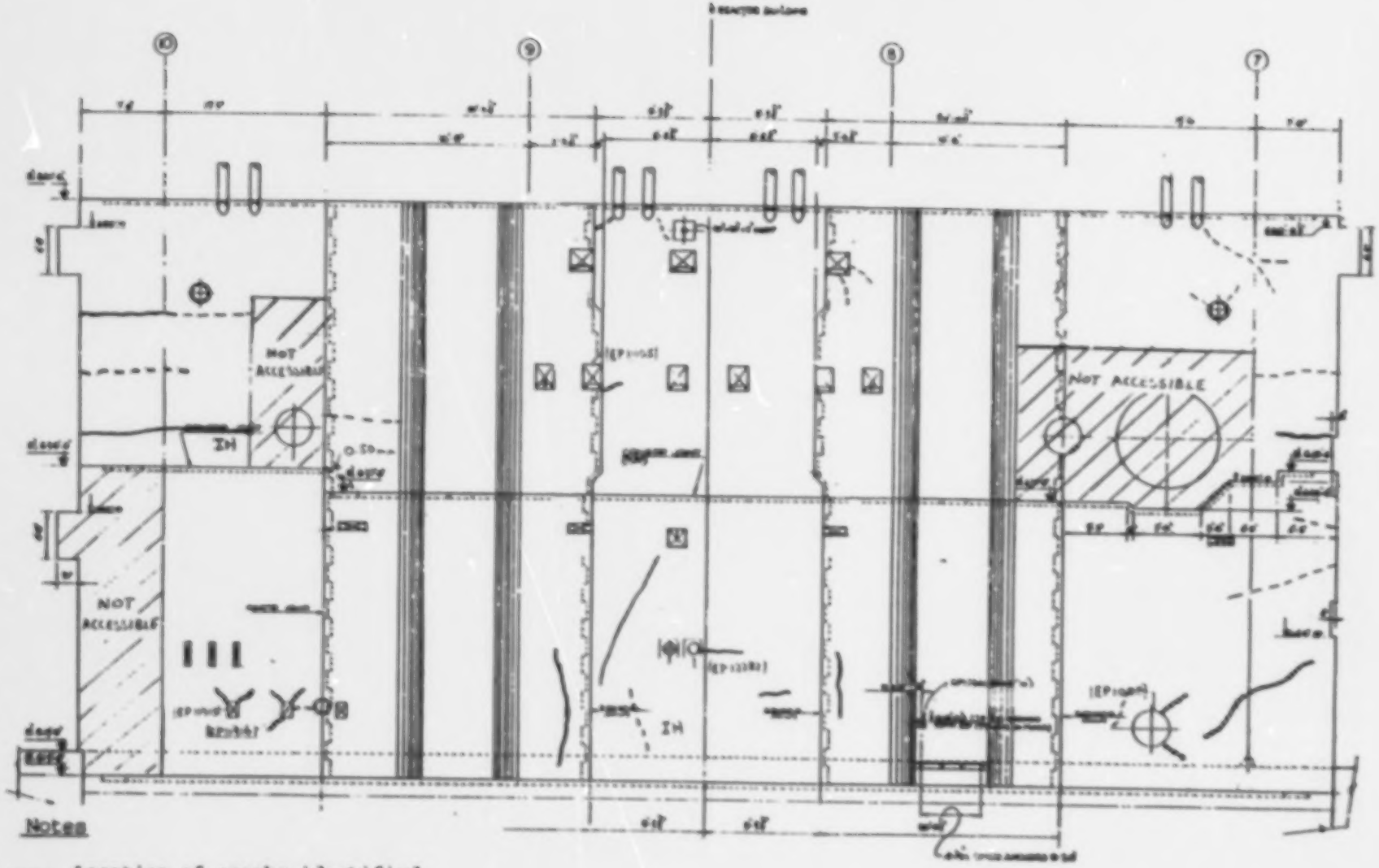
Notes

—— Location of cracks identified previously.

- - - Location of cracks identified during this inspection, in 1990.

IH Location of impact hammer readings.

FIGURE 1
BRUCE NGS 'B', RB#5
REACTOR BUILDING
EXTERIOR NORTH WALL



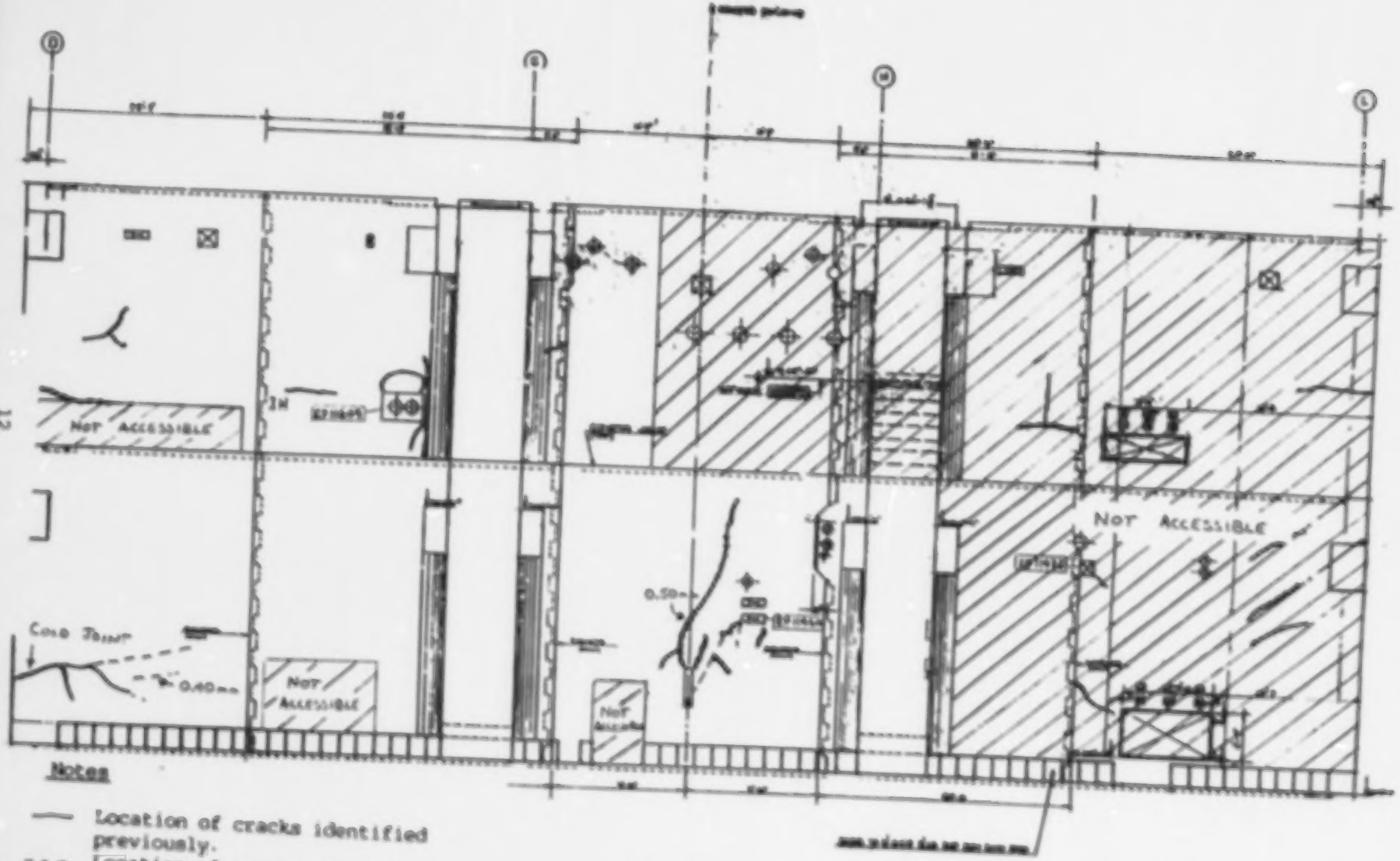
Notes

—— Location of cracks identified previously.

- - - Location of cracks identified during this inspection, in 1990.

IH Location of impact hammer readings.

FIGURE 2
BRUCE NGS 'B', RB#5
REACTOR BUILDING
EXTERIOR EAST WALL



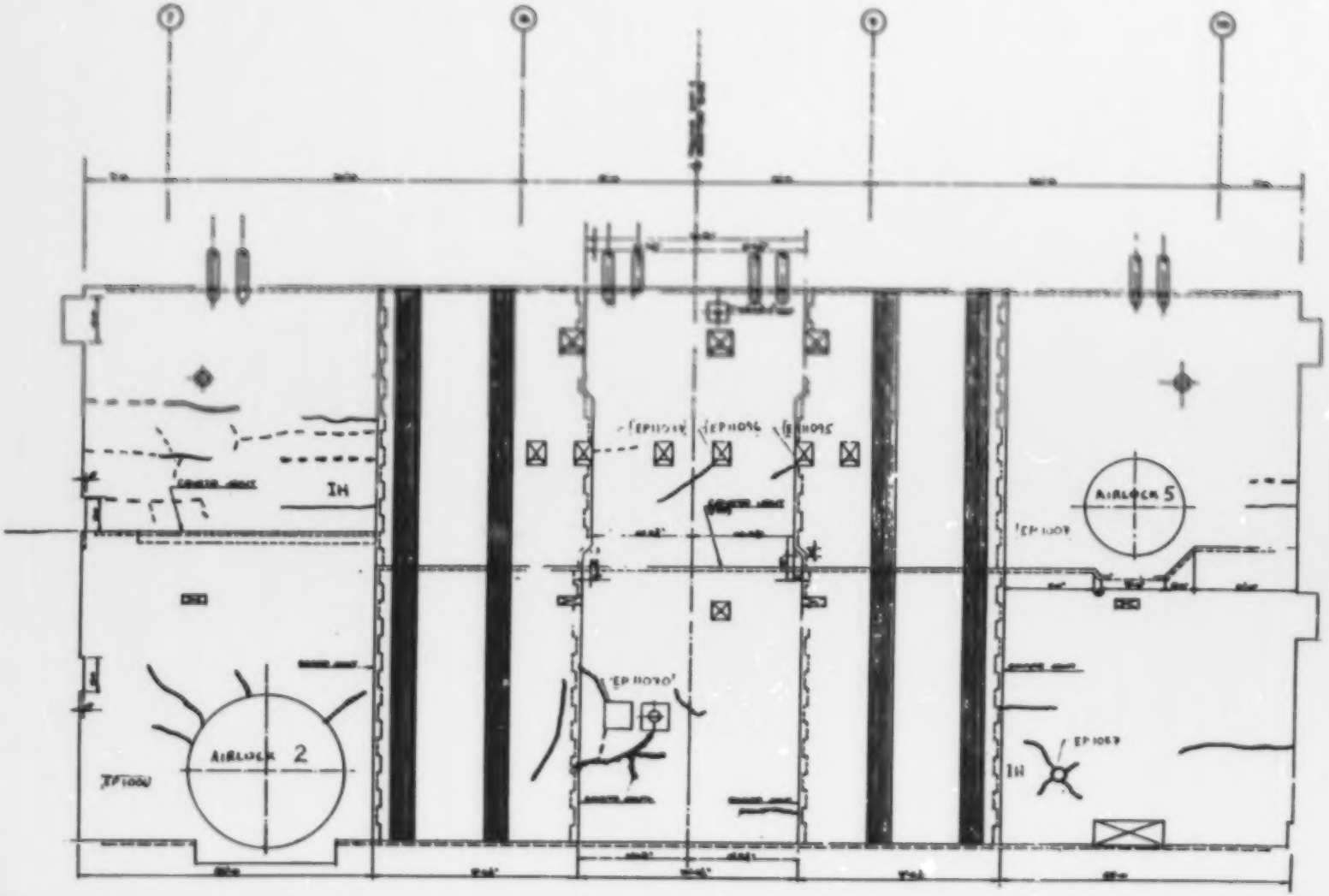
Notes

—— Location of cracks identified previously.

- - - Location of cracks identified during this inspection, in 1990.

1H Location of impact hammer readings.

FIGURE 3
BRUCE NGS 'B', RB#5
REACTOR BUILDING
EXTERIOR SOUTH WALL



Notes

—— Location of cracks identified previously.

- - - Location of cracks identified during this inspection, in 1990.

IH Location of impact hammer readings.

FIGURE 4
BRUCE NGS 'B', RB#5
REACTOR BUILDING
EXTERIOR WEST WALL

Figure 5 - Typical crack present in the perimeter walls of the reactor building. The crack width at this location was 0.50 mm.

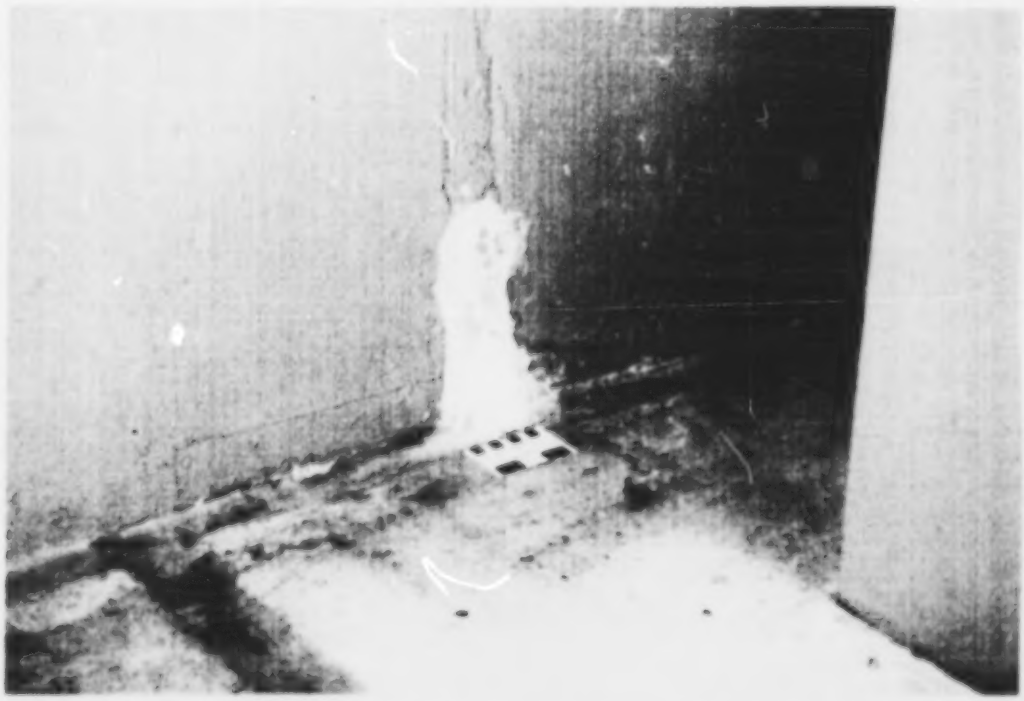
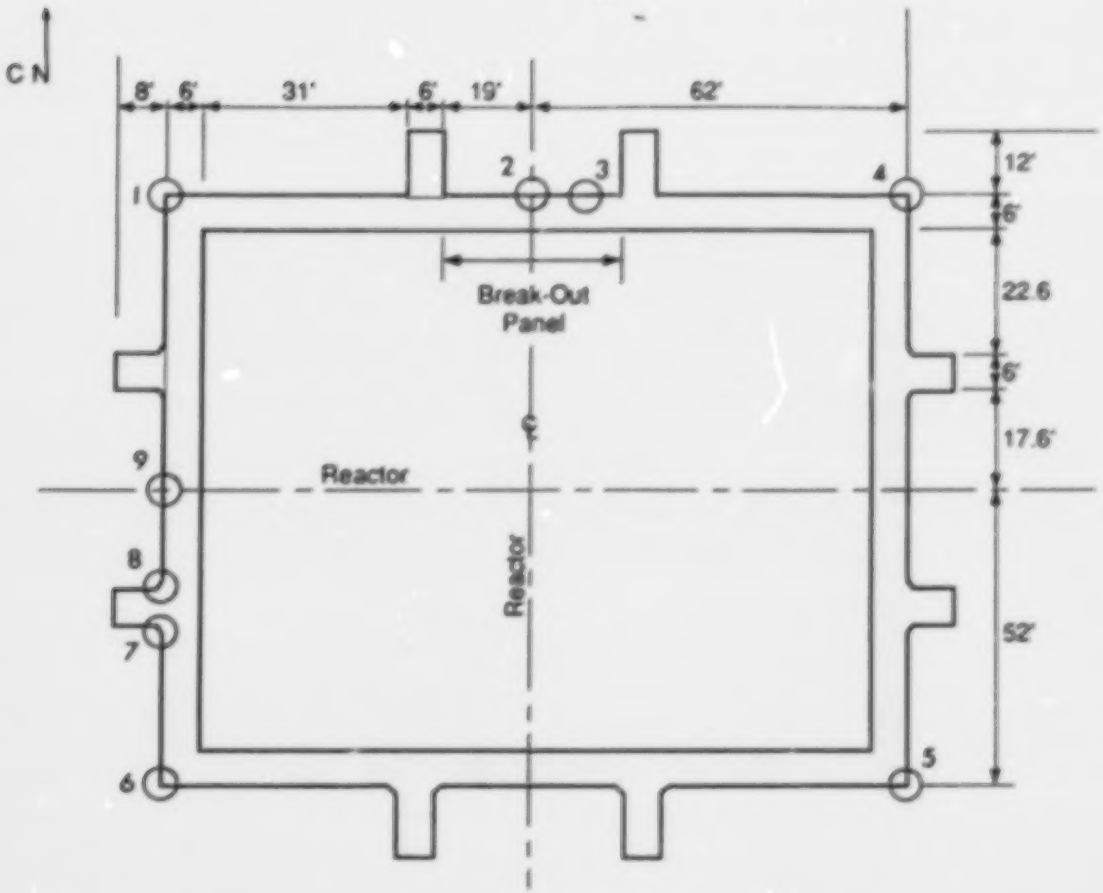


Figure 6 - Deposits observed near the north end of the east perimeter wall of the reactor building at Elevation 615'.

Figure 7 - Deposits in the vicinity of EP 12187 at the east end of the north wall of the reactor building at Elevation 639'. The location of cracks, identified previously, have been indicated with black arrows.



○ - Critical Areas Where Concrete Should Be Examined

FIGURE 8

BRUCE NGS "B" REACTOR BUILDING
PLAN VIEW
LOCATION OF HIGH STRESS AREAS

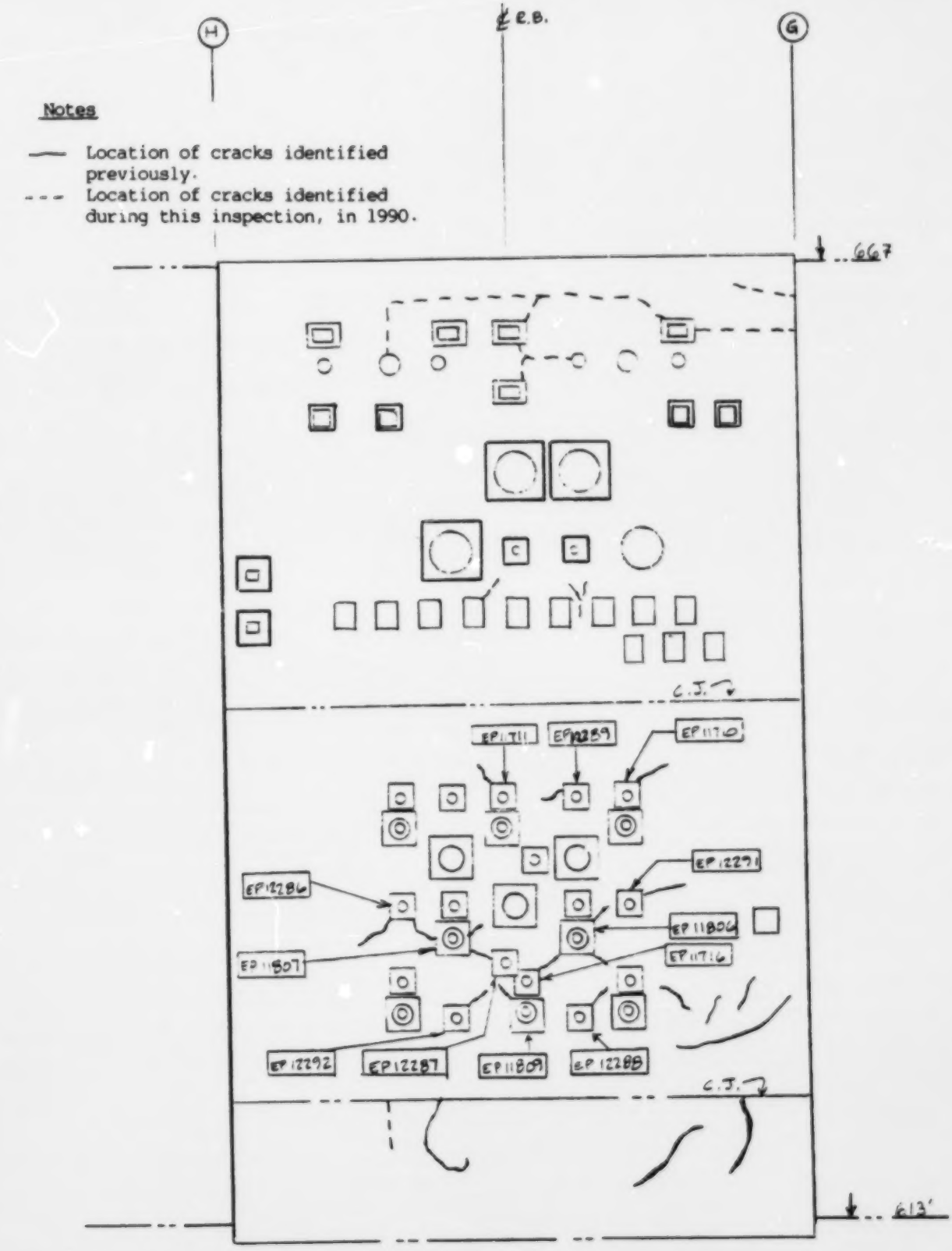


FIGURE 9
BRUCE NGS 'B', RB#5
BREAKOUT PANEL

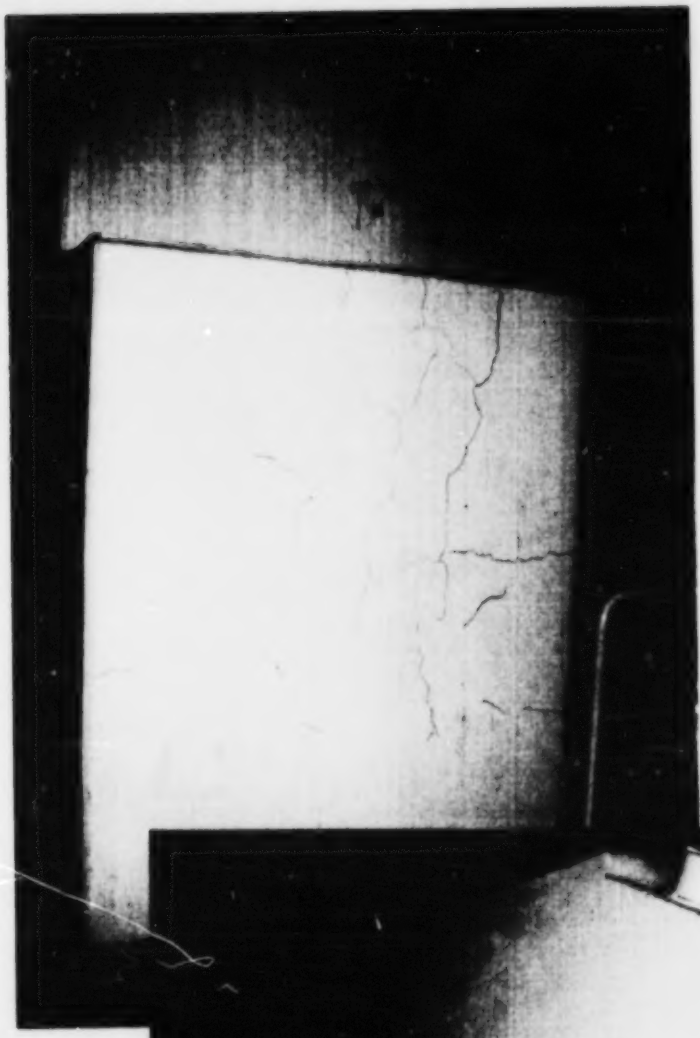


Figure 10 - Randomly oriented cracks in the north end of the west girder at Elevation 693'.

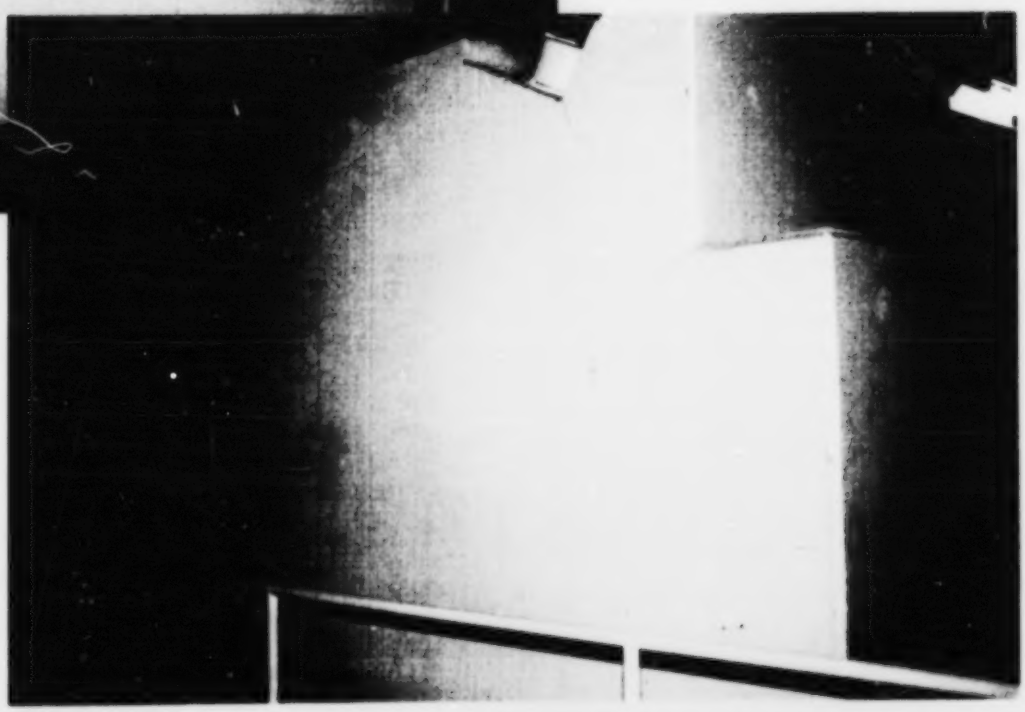


Figure 11 - Typical cracks present around the anchorage zones in the main girders. Shown above is the east side of the north end of the west girder at Elevation 693'.

Figure 12 - The exposed grease tendon at the north end of the west girder at Elevation 678'. Leakage of grease was reported from this anchor cap and the vent tube embedded in the concrete above (See arrow).

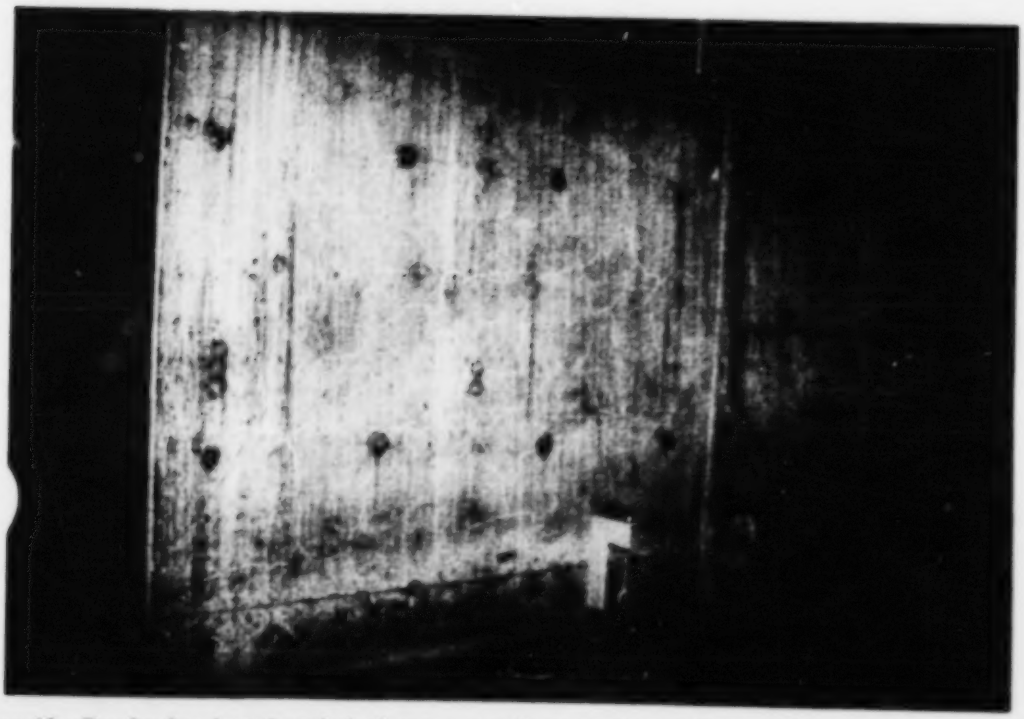
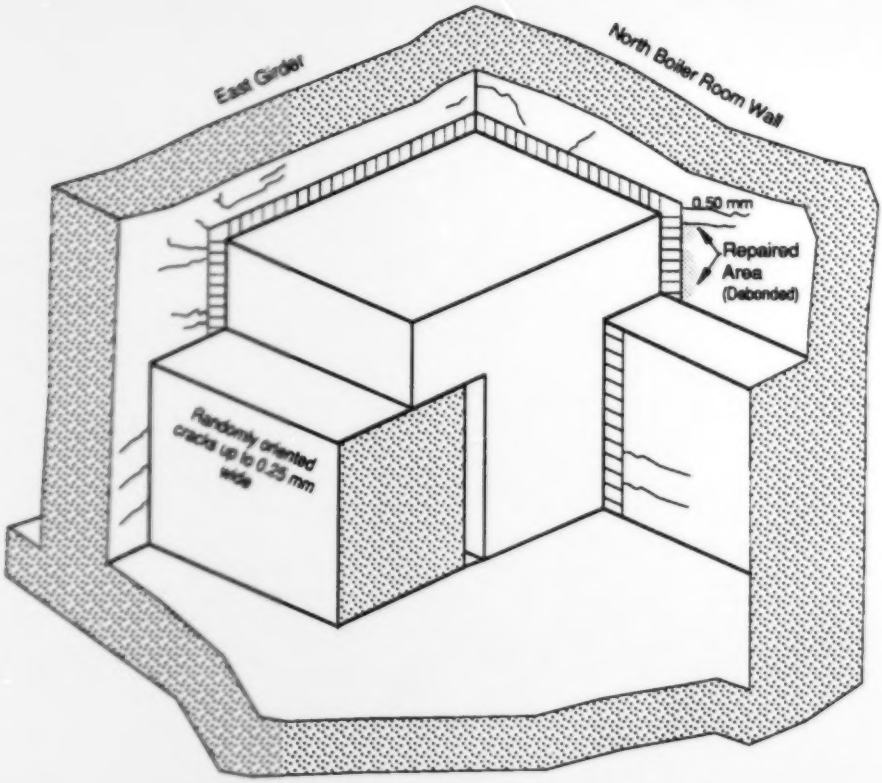


Figure 13 - Randomly oriented cracks in the concrete adjacent to the northwest preheater enclosure (Figure 17). It could not be determined whether these cracks had developed since 1987.

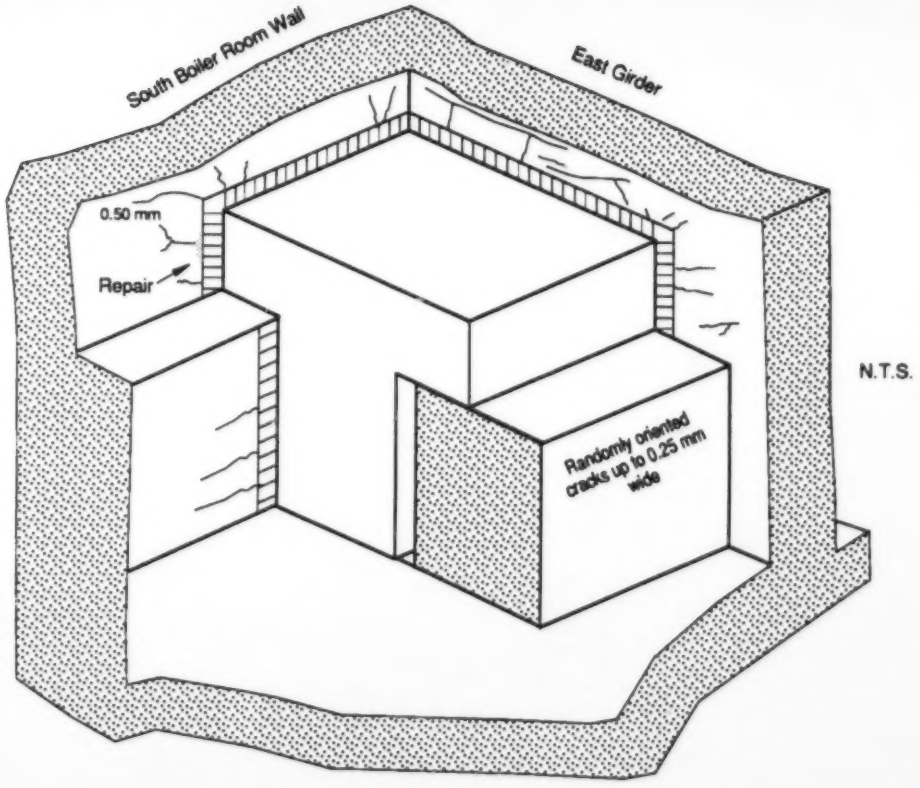


N.T.S.

General Notes: Crack width <0.25 mm unless otherwise noted.
No signs of concrete deterioration except for the cracks and debonded repairs identified in the figure.

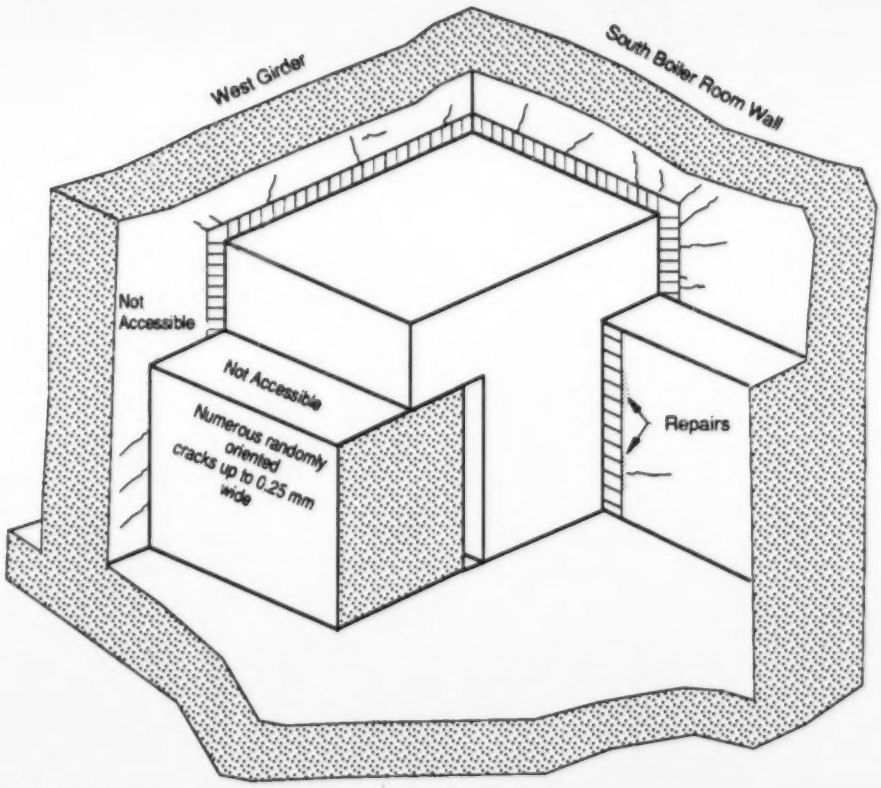
FIGURE 14

UNIT 5 - NORTHEAST PREHEATER ENCLOSURE CONCRETE INSPECTION



General Notes: Crack width <0.25 mm unless otherwise noted.
No signs of concrete deterioration except for the cracks identified in the figure.

FIGURE 15
UNIT 5 - SOUTHEAST PREHEATER ENCLOSURE
CONCRETE INSPECTION

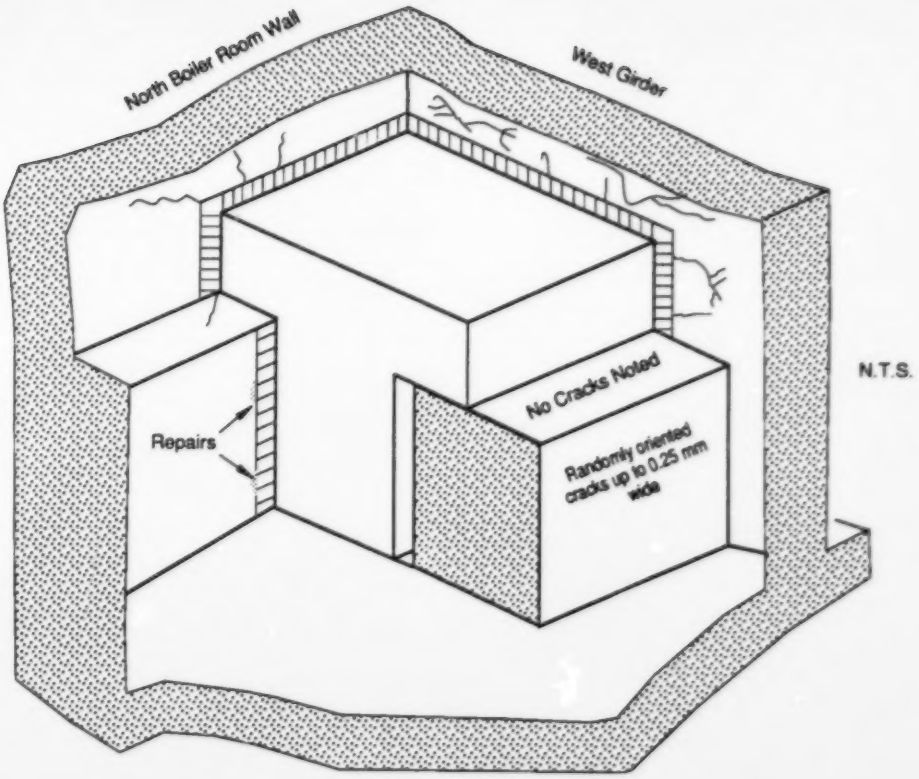


N.T.S.

General Notes: Crack width <0.25 mm .
No signs of concrete deterioration except for the cracks identified in the figure.

FIGURE 16

UNIT 5 - SOUTHWEST PREHEATER ENCLOSURE CONCRETE INSPECTION



General Notes: Crack width <0.25 mm.
No signs of concrete deterioration except for the cracks identified in the figure.

FIGURE 17

UNIT 5 - NORTHWEST PREHEATER ENCLOSURE CONCRETE INSPECTION

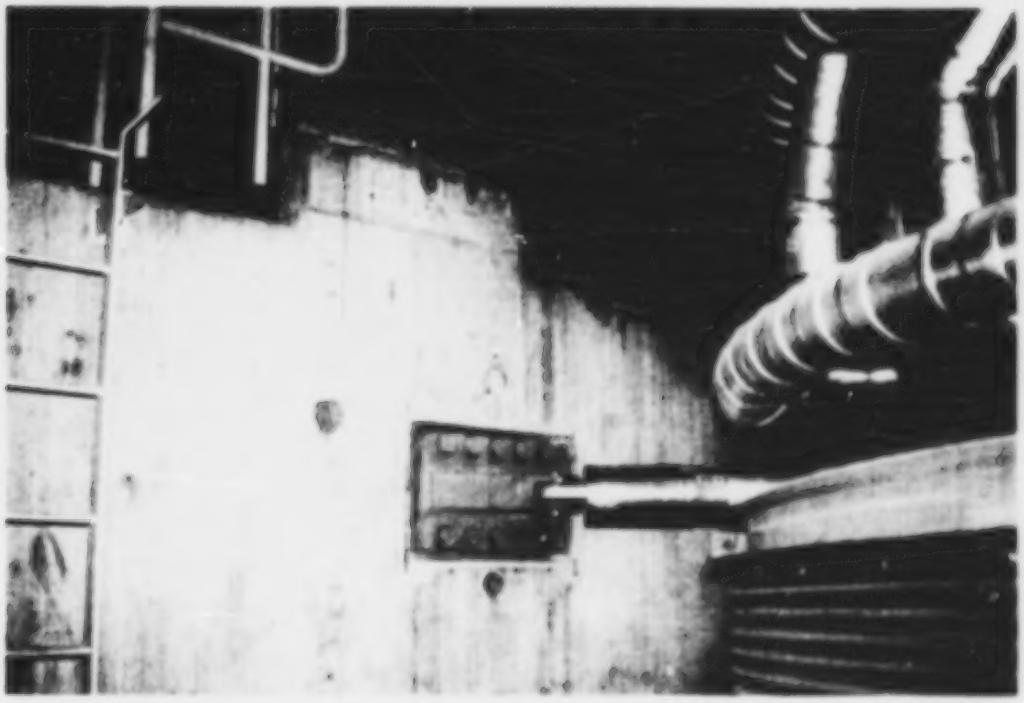


Figure 18 - The concrete in the vicinity of the beams supporting the steam generators and the embedded parts at the braces for the steam generators was inspected.

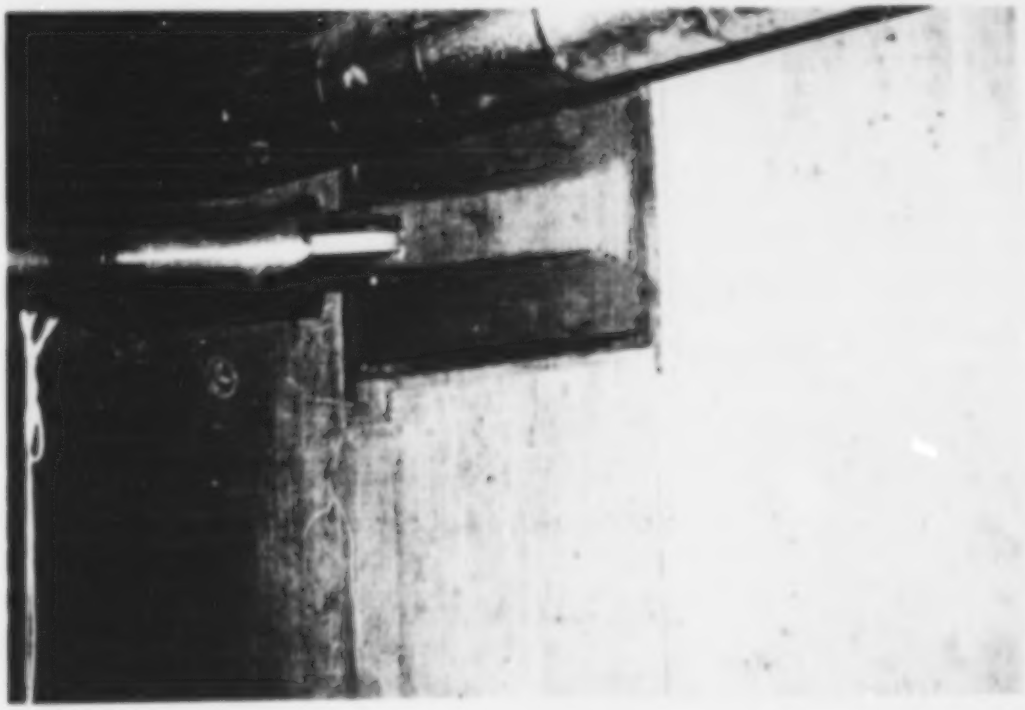


Figure 19 - Cracks, with widths up to 0.50 mm, were observed extending from the embedded parts for the braces for the steam generators.

Figure 20 - Typical cracks observed in the wall of the fuelling machine duct at Elevation 591'. (width <0.25 mm)

Figure 21 - Repair to a crack identified in 1987. This repair is located in the wall of the fuelling machine duct at the vertical construction joint between Units 5 and 6 at Elevation 579'.

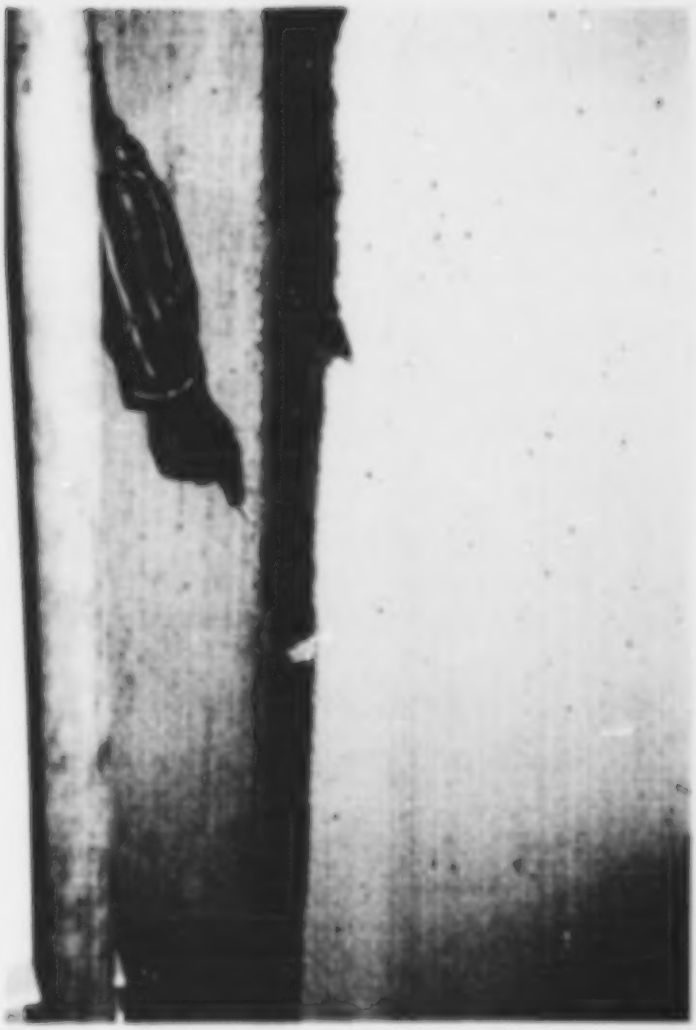


Figure 22 - Minor spalling observed along a vertical construction joint in the fuelling machine duct at Elevation 591'. This area was unchanged since 1987.